

August 25, 2008

Topic: Bosch response to the Subcommittee on Networking and Information Technology Research and Development (NITRD) Request for Input (RFI)

Bosch has had the opportunity to attend several recent Cyber-Physical Systems (CPS) workshops including the *Workshop on High-Confidence Automotive CPS* (April 07), the *Embedded Systems to Cyber-Physical Systems Workshop* during CPS Week (April 07), and the *Joint Workshop on High Confidence Medical Devices, Software, and Systems (HCMDSS)* and *Medical Device Plug-and-Play (MD PnP) Interoperability* (June 07).

The quality and diversity of research ideas as well as the distinguished list of participants were found to be quite impressive. From these meetings, we have the following observations and suggestions:

Development and execution of multi-agency/multi-disciplinary programs

- Coordination: Since CPS is a broad, multi-disciplinary topic, continued coordination between the complex set of government, academic and industry participants is especially important.
- Discussion: Experts from many fields will have useful contributions to make to CPS. The workshops and break-out sessions help facilitate constructive discussion and goal-setting.
- Awareness: It is important to keep industry aware of the latest CPS developments and funding opportunities. The CPS workshops have addressed this need well so far.
- US/EU Cooperation: To the extent possible, international cooperation is beneficial as many corporations are multi-national. Industry is reluctant to 'pay twice' for the same research in different countries, so a lack of coordination can mean that one country loses out entirely.

Strategic goals, key challenges, opportunities and research priorities

- Good fit to Bosch business: CPS domains are strongly related to current and future products and services sold by Bosch in three business sectors¹:
 - Automotive Technology (€27.2B / \$6.2B)
 - Industrial Technology (€5.9B / \$1.3B)
 - Consumer Goods and Building Technology (€11.7B / \$2.0B)

¹Note: figures are expressed as sales worldwide in billion EUR / North America in billion USD for 2007

- Research challenges: Many research challenges were discussed at the workshops. We found the following challenges relevant and compelling:

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- Predictable system integration through compositionality
- Architectures and tools for reliable and resilient CPS systems
- Smart environments and scalable digital services
- Verification and Validation (V&V) of model-based design
- Efficient manufacturing and logistics
- Achieving high confidence and interoperability in medical devices, software, and systems

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Transition R&D results; Government, commercial, academic interactions

- Funding opportunities: Bosch engages in many research collaborations with individual universities and multi-university research centers. If government funding is available for the university partner, this helps lower the barrier to entry to setting up collaborations.
- Identifying partners: Ultimately, transfer of technology occurs between individual partners. The CPS meetings facilitate good partnerships.

Examples that illustrate the impact of realizing the vision, achieving the proposed goals, and meeting the identified challenges

- CPS visionaries: Since CPS is a new topic, there are not many completed projects yet. However, the workshops featured many forward-thinking speakers with insightful observations:
 - Dr. Jeannette Wing, National Science Foundation: Cyber-Physical Systems is the #1 priority. Two important classes of systems are covering: Embedded and Real-Time with Pervasive and Mobile.
 - Dr. Alan Taub, General Motors: Automotive represents the intersection of cyber-physical systems problems in other areas.
 - Dr. Helen Gill, National Science Foundation: In the next five years, embedded computing components are expected to account for a significant percentage of product value; up to 40% in some areas.

In summary, future NIT capabilities are needed to address the business areas and research challenges mentioned above. With respect to roles, the NITRD Program offers value by organizing stakeholder meetings, facilitating networking and providing funding opportunities. The academic community can provide a sound scientific foundation for the advancement of CPS. Since CPS challenges are shared globally, coordination of international agencies is important to avoid potentially wasteful double work on pre-competitive topics.

We look forward to the opportunity to participate in future activities regarding

Networking and Information Technology and Cyber-Physical Systems

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